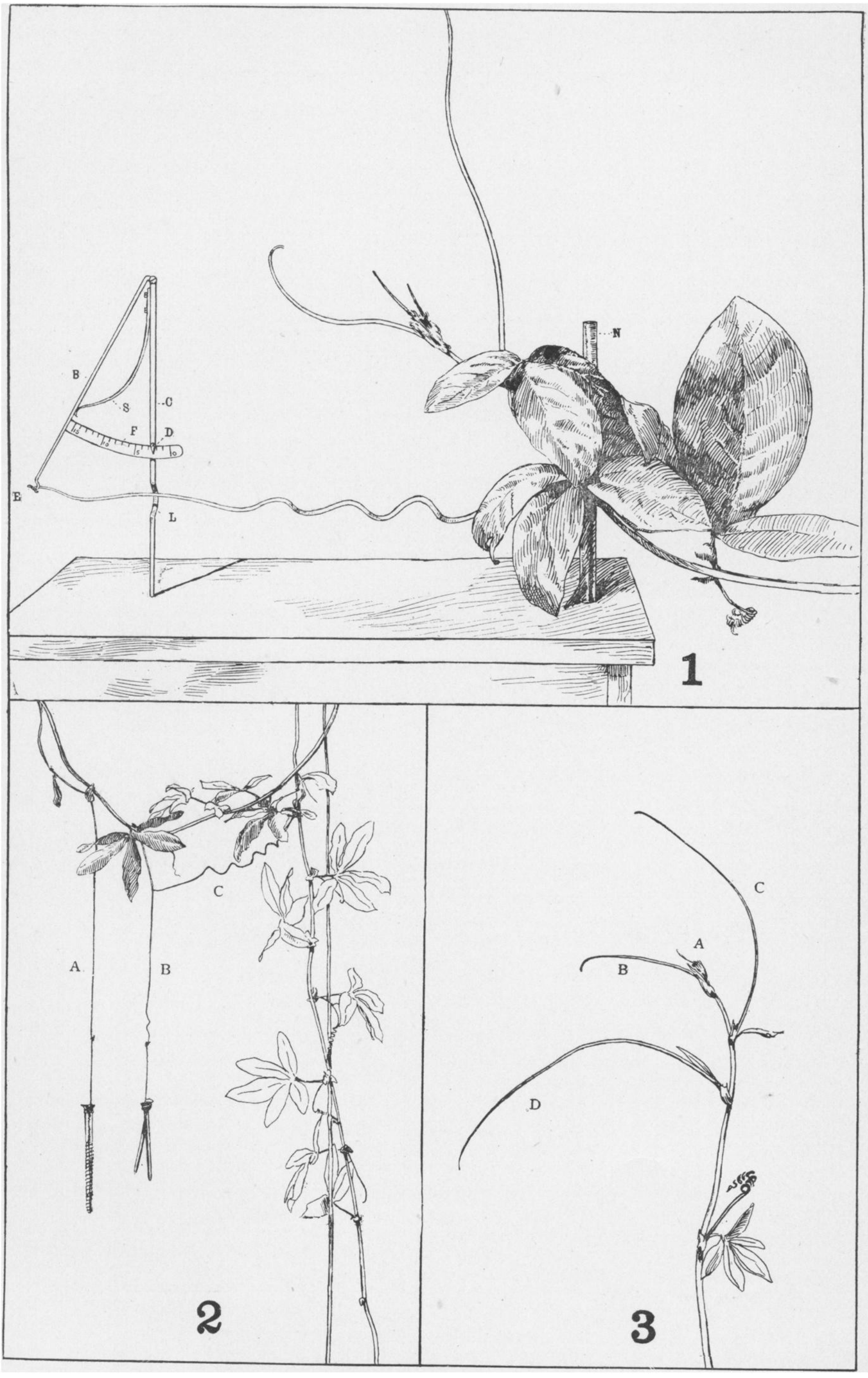

MacDOUGAL on PASSIFLORA.

7. C. DRUMMONDII: *H. Drummondii* Torr. & Gray.
8. C. TEXANA: *H. Texana* Fisher.
9. C. VIRGATA: *H. microphylla* Torr. (Specific name preoccupied under *Cæsalpinia*.)
10. C. INTRICATA: *H. glabra* Fisher, var. *intricata* (Brandg.) Fisher.
    Var. GLABRA: *H. microphylla* Torr., var. *glabra* (nomen nudum) Watson. *H. glabra* Fisher.
11. C. CAUDATA: *H. caudata* Gray.
12. C. BRACHYCARPA: *H. brachycarpa* Gray.
13. C. MULTIJUGA: *H. multijuga* Watson.
14. C. MELANOSTICTA: *H. melanosticta* (Schauer) Gray.
    Var. PARRYI: *H. melanosticta*, var. *Parryi* Fisher.
    Var. GREGGII: *H. melanosticta*, var. *Greggii* Fisher.
15. C. CANESCENS: *H. canescens* Fisher.
16. C. JAMESII: *H. Jamesii* Torr. & Gray.
17. C. FRUTICOSA: *H. fruticosa* Watson.

There also may be added the following South American form, from U. S. of Colombia, that has come under my observation, and which may possibly extend to the isthmus:

18. C. VISCOSA: *H. viscosa* Hook. & Arn.

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The tendrils of Passiflora caerulea.

D. T. MAC DOUGAL.

WITH PLATE X.

II. External phenomena of irritability and coiling.

In the preceding paper[1] attention was called to the more apparent features of the development, minute structure and arrangement of the tissues, with a view to determining their value as factors in the coiling movements consequent upon irritation of the lower surface during the period of normal activity of the organ. The results recorded in this and the preceding paper were obtained by the study of plants in the green-house of the Purdue Experiment Station,[2] during the

[1] BOTANICAL GAZETTE, XVII, 205.

[2] I am indebted to Dr. J. C. Arthur for his kindness in placing at my disposal the facilities of the green-house, laboratory and apparatus, and in giving me the use of his private library, together with much valuable advice. I am also under obligations to Miss Katherine E. Golden, Assistant Botanist, for material aid.

months January—April, and September—December, 1892. The observations were extended to include *P. Pfordti* of the gardeners. The temperature varied between 16 and 35°C.

It is of interest to note that both of these forms exhibited marked nutation of the terminal internodes of the stem, since in the species examined by Darwin such was found to be the case only in *P. gracilis.*[3]

This circumnutation of the tendril and the internode bearing it begins when both are quite rudimentary (fig. 3). These movements with the individual movements of the yet immature internodes below combine to sweep the tendril through a large space during its period of greatest activity, thereby greatly increasing the probability of coming in contact with some object which may serve as a support. While this correlation is an obvious advantage, yet it must be borne in mind that nearly half the time the tendril is waving through the air with its non-sensitive surface forward, and hence could not grasp a support should it meet one. It is not necessary to suppose, however, that the tendril has reached the stage of the highest possible usefulness to the plant.

When the moving tendril, after it has attained a length of 4 or 5^{cm}, brings its sensitive surface in contact with an object which acts as a stimulus, a curve is formed at the point of contact in a time varying from 30 seconds to 2 minutes. If this happen in the early stages of growth, the curve is slight, the tissues are weak, and the tendril is dragged past or away from the support. Should the tendril have reached an approximately mature stage, the curve will be formed more rapidly, and the strengthened tissues hold the hook form given to it, and curve still further around the object. If we strike a rigid pole with a rattan cane, the curve formed will be similar to that of the young tendril, and if we strike the pole with a rope one end swinging free, the curve of the mature tendril will be obtained.

In this connection it was thought important to note to what extent the tendril would respond to various kinds of stimuli. Drops of water at ordinary temperature thrown either gently or forcefully against the tendrils produced no curvature. The contact of the ordinary metallic salts acted similarly. But if the tendril were submerged in these liquids the induced osmotic action quickly caused curves.[4]

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[3]Climbing Plants, p. 153. Vines: Phys. of Plants, p. 486.

The contact of mercury was without effect,[5] but if the meniscus of a vessel of mercury be brought forcibly against the tendril, distinct curvatures resulted.

With solids, however, it was found that it would respond to a contact as light as that made by a piece of no. 40 cotton thread, 1^{cm} in length. The results of contacts from objects of glass, woods, metals, stones, fibres, parts of its own and other plants were practically alike, and the rapidity and amount of response depended altogether upon the force of impact and roughness of the surface rather than the composition of the body. No extended experiments were made with electrical stimuli, but no results were obtained by the use of the current from a Leclanché cell.

If the temperature of the water in the previous experiment were raised to 40°C. curves were produced; or if a small rod heated to 50°C. were held near the tendril like results followed. If the water were in the form of snow or ice no curvatures could be obtained, although the hard crystals must have given a very distinct mechanical contact. The results from these high and low temperature stimuli are doubtless due to their direct influence on the osmotic action of the cells, since in the experiment with the heated rod the tendril can be made to curve backward.

Darwin notes that the tendrils of *Bryonia dioica*, and also *Echinocystis lobata*, would not form curves when mutually interlocked. His generalizations can not be extended to the species of Passiflora examined. If a small portion of an excised tendril be placed on an active tendril a temporary curve results, and it was noticed that two tendrils brought against each other almost always formed curves, and the fact that they did not always interlock was due to the fact that both were in rapid motion in opposite directions, and were quickly dragged past. Should any of the tendrils be fixed taut the other may coil around it as has been demonstrated numerous times (fig. 2, c). In one case five tendrils formed a mass of mutual coils. The tendril has also been noted to grasp and crush into a mass in its coils the leaves of its own body, perhaps the one from its own axil. Such action could not even remotely be of any use to the plant, and in view of these facts it is

[4] BOTANICAL GAZETTE, XVII. 207.

[5] See also Pfeffer: Untersuchungen aus dem Botanischen Institut zu Tübingen, I. 491.

impossible to ascribe to them any great degree of selective intelligence.

The tendrils can coil in such manner as to fasten to almost any object except a polished plane surface. If the object be a cord or a twig the free end coils around it as in the rope experiment, while the portion between the plant and the support is thrown into spiral coils. If a board whose width is nearly equal the length of the tendril be placed in contact with it, the tip will hook around the farther edge while a few spirals are formed which lie flat on the surface. Thus it will be seen that the size of the object which may be grasped is limited only by the length of the tendril, while it can grasp an object however small since the tendril can coil so closely as to obliterate the central enclosed space. This adaptation was still further shown by the manner in which it fastens to the crevices of a brick wall. In doing this the tendril tip finds its way into the small surface cavities of the bricks and forms coils, filling up the cavity in such manner that it can not be dislodged without rupturing the tissues.

Tendrils thrust into smooth glass tubes 2^{mm} in diameter formed curves throughout their entire length, while the more flexible tip formed a solid spiral completely filling up the bore of the tube. It required a force of 10–20^{gm} to dislodge such tendrils. Still others placed in tubes scarcely larger than themselves could not be withdrawn without breaking or crushing the tube.

If a tendril during its period of irritability does not come in contact with any object reacting as a stimulus, it will, on completing its growth, slowly form into a continuous right or left handed irregular spiral.

Should the tendril grasp some object with a portion of its tip, the portion in contact with the object grows slightly in length and by its manner of curvature forces its tip farther around the object if it is not too large, and at the same time increases the thickness of the part in contact, as a reactive result of the pressure. The tendril may grasp an object any time during its period of activity, but the part between the support and base will not form spirals until it has attained its maturity, which is from a few hours to two days later. Now the immediate cause of coiling is the inequality of length of the upper and lower sides of the tendril. How this inequality is brought about need not concern us at this point. If the tendency to curve were strongest at the tip and decreased to

zero at the basal portion, the free tendril would coil in the form of a helix and no torsions would result. The strength of the curving power, and of the tendril, are so proportioned that the resulting spirals are all 0.3^{cm} to 0.5^{cm} in diameter and can not lie concentrically, but must form side by side. This means, of course, that torsions are set up. In the free coiling tendril it can revolve and relieve these torsions. In the tendril fastened at both ends, however, this is impossible and if the spirals were all in one direction the torsion would be great enough to work serious injury. The fastened tendril begins to form spirals either near the base or the support on reaching maturity. This part coiling with its spirals all in one direction of course twists the contiguous straight part of the tendril. This twisting continues until the induced torsion is stronger than the coiling force of the first part, and then the twisted part forms coils in the opposite direction in obedience to its own torsion. The portion in which the two forces are equalized will be nearly straight. The remainder of the uncoiled tendril is acted upon similarly until it is coiled in two to seven portions separated by straight parts. The number of the portions will be determined by the relative value of the coiling force and the resistance of the tendril. While the number of spirals in any portion may not be the same as in another portion of the same tendril yet the total number of turns in either direction are invariably equal. The time elapsing between fastening to a support and the formation of spirals leads to the conclusion that the latter is not a direct result of irritability, but rather a function of the mature tendril.

When a straight tendril fastens to a support and afterward forms spirals in the portion between its base and the support, it must tend to bring these two points nearer, unless the tendril has at the same time a growth in length to compensate for the spirals, such as was found to be the case in Cucurbita by Penhallow.[6] Extended observations were made to determine if the distance between the base of the tendril at the body of the plant and the support were brought any nearer, and if so what force was exerted in so doing. Repeated measurements disclosed the fact that the tendril drew the portion of the vine near its base toward the support a distance of 1 to 6^{cm} or as much as one-third its length.

Weights of three grams upward were suspended from the

[6] Canadian Record of Science, II. 242. Oct. 1886.

tips of tendrils by means of loops of soft cotton cord to determine their lifting strength. With weights less than six grams many close spirals were formed lifting the weights several centimeters. With the increase of weight, more open spirals resulted. Still higher only weak curves were made, while tendrils weighted with twenty grams were held entirely straight, and this may be safely taken as the limit of the lifting power (fig. 3). These effects, however, are modified by effect of the traction of the weights on the tendril.[7]

The results obtained by the dynamometers are doubtless of greater value. Of these, three types were used. One form consisted of a spiral spring of brass suspended from a hook in an upright wooden standard after the manner of the Joly gravity balance. The tendril is fastened to the lower end of the spring and the amount of tension determined by an arbitrary scale. The second form was the lever dynamometer which is in general use and needs no description here.[8]

The most satisfactory results, however, were obtained from the use of Vöchting's dynamometer.[9] This machine is designed for use with a clinostat, but can be used in determining tensions of all kinds. It is simple, convenient and reliable. (See plate X.) It consists essentially of two compass arms of metal 10^{cm} and 6^{cm} in length, separated by a spring (s). The long arm (c) carries the spring and the short pointer (d) and is curved back a short distance below the pointer (l) and tapers uniformly throughout to the lower end which is a sharpened point. The shorter arm (b) joins the longer arm by an ordinary hinge joint. This arm tapers to the lower end, terminating in a small hook (e), and carries the arc scale (f) which slides under the pointer. The scale is marked into fifteen divisions so arranged that a pull on the hook (e) will be indicated in grams by the pointer. The spring (s) is made of gold for greater reliability, and is fastened to the long arm by two small screws. The other end slides freely along the shorter arm as the pressure varies. In the plate the machine is shown registering a tension of $2\frac{1}{2}^{gm}$ of a tendril of *Passiflora Pfordti.*

The plant at the base of the tendril is attached by cords to an iron post (n) driven firmly in a board. The long arm of the dynamometer is driven into the board in such position that

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[7] W. Pfeffer: Ber. Verhandl. K. Sachs. Gesell. Wiss. v. 638–643. (1892.)
[8] Pfeffer: Die periodischen Bewegungen der Blattorgane, 1875.
[9] Berichte der. deutchen bot. Gesellschaft, VI. 279. (1888).

the straight tendril will pass the curved portion without touching, and catch the hooked end of the short arm with its curved tip. Any tension set up is indicated directly on the scale. The tendrils tested with this type of dynamometer exhibited tensions of 3 to 10^{gm}.

The function of the tendril is doubtless to pull the growing shoot up toward the light and fix it to a support. It occupies a supra-axillary position and the internodes are from 3 to 10^{cm} in length. The work of each tendril as it in succession comes to maturity is to lift its internode and the undeveloped internodes of the growing shoot. On testing it was found that this portion of the plant never reached a weight of 1^{gm}, and the amount to be lifted by two adjoining tendrils rarely exceeds 1.5^{gm}. Thus it will be seen that each tendril is capable of doing the work of many. The value of this provision is apparent when it is known that not all of the tendrils are able to reach supports, others are injured or rendered incapable of grasping objects by the force of the winds, and that the firmness with which a plant is held has a direct influence on its growth.

The coiling of the attached tendrils and the subsequent strengthening of their tissues give them the elasticity of springs and enable them to withstand severe shocks and strains without injury. The force required to tear a plant from its supports must first straighten the coils and then rupture the tendril. No measurements were made of the tensile strength, but it was found that normally coiled and mature tendrils required a force of 350 to 750^{gm}—the weight of several feet of the plant body—to break them, so that the probability of a vine, firmly anchored by dozens of these tendrils, being torn from its fastenings, is very remote.

Briefly summarized, the tendrils and terminal internodes of the two species of Passiflora examined show circumnutation. The tendrils are sensitive to contact of solids, and liquids at a temperature of 40°C., and are non-sensitive to liquids at ordinary and low temperatures, unless they are so applied as to induce direct osmotic action, and to slight electrical stimuli. Coiling around an object takes place on contact, while formation of spirals takes place on maturity. The formation of the spirals exerts a tension of three to twenty grams, shortening the tendril one third of its length, and a mature tendril can withstand a strain of 350 to 750^{gm}.

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EXPLANATION OF PLATE X.

Figure 1. *Passiflora Pfordti;* Vöchting's dynamometer attached to tendril; B, short arm, C, long arm, D, pointer, E, hook, F, scale, L, curve of long arm, S, spring, N, iron post.

Figure 2. *Passiflora cærulea;* A, tendril carrying weight of nineteen grams, slightly curved near base, B, tendril carrying weight of nine grams, spiral near tip, C, tendril grasping tendril B, which it has pulled from the perpendicular.

Figure 3. *Passiflora cærulea;* A, growing tip of shoot with undeveloped tendrils, B, tendril slightly sensitive and nutating, C, tendril capable of coiling, D, tendril nearly mature—in the period of highest activity.

The limitation of the term "spore."

CONWAY MAC MILLAN.

Every one who has attempted to define his terms of daily use has probably met with the same experience that the writer might describe. Words, easily definable at first, become more and more vague as their implication is more fully understood. In view of the scantiness of botanical terminology, although it is one of the richest of scientific vocabularies, there is great need that the import of common terms should be examined with much care to avoid the errors of over-, or under-definition. Every work that appears presents some new and generally barbarous verbal technicalities that tend rather to cloud than to clarify perception, For example in that most excellent little compendium on the cryptogamic plants, lately published from Bennett and Murray, one is grieved to find that the word "sperm," properly employed in plant, as in animal, biology, is diverted to a peculiarly unnecessary meaning and is taken as a synonym of the phrase "fertilized egg," when it would have been much preferable to unify the terminology by calling the antherozoid of the plant a "sperm," and thus recognizing what it is necessary to recognize as fully as may be that the animal and the plant are alike, for the higher groups of organisms, in producing sexual cells and that these cells are, even in their intimate mitotic phenomena of development, strictly analogous, if not absolutely homologous.

At present I wish to speak in particular about the use of the word "spore" in botanical writing, and it is not intended to offer any historical or highly exhaustive discussion at this time, but simply to show how under the general term there are a number of ideas that clear thinking demands should be kept separate. In the first place it may be noted that the